REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	**2. REPORT TYPE**	**3. DATES COVERED** *(From - To)*
15-07-2010	Final	

4. TITLE AND SUBTITLE
Test Operations Procedure (TOP)
10-2-175 Tents and Shelters

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHORS

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
US Army Aberdeen Test Center (TEDT-AT-WF-S)
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Aberdeen Proving Ground, MD 21005-5055

8. PERFORMING ORGANIZATION REPORT NUMBER
TOP 10-2-175

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Test Business Management Division (TEDT-TMB)
US Army Developmental Test Command
314 Longs Corner Road
Aberdeen Proving Ground, MD 21005-5055

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)
Same as item 8

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited.

13. SUPPLEMENTARY NOTES
Defense Technical Information Center (DTIC), AD No.:
This TOP supersedes TOP 10-2-175, dated 19 March 1984.

14. ABSTRACT
This TOP describes procedures for testing rigid wall, soft wall, and hybrid shelters and their accessories, tools and equipment. Tests include Initial Inspection, Safety and Health, Physical Characteristics, Blackout/Infrared Detectability, Roof Load, Durability, Electromagnetic Interference (EMI), Transportability, Environmental, Human Factors Engineering (HFE), Reliability, Availability and Maintainability (RAM), and Final Inspection.

15. SUBJECT TERMS
Rigid Wall Shelters
Soft Wall Shelters
Hybrid Shelters

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT	**B. ABSTRACT**	**C. THIS PAGE**			**19b. TELEPHONE NUMBER** *(include area code)*
Unclassified	Unclassified	Unclassified	SAR	45	

US ARMY DEVELOPMENTAL TEST COMMAND
TEST OPERATIONS PROCEDURE

*Test Operations Procedure 10-2-175 15 July 2010
DTIC AD No.

SHELTER SYSTEMS

*This TOP supersedes TOP 10-2-175, AD No. A139558, 19 March 1984.

1. SCOPE.

This Test Operations Procedure (TOP) provides test methodology for determining the technical performance, safety, and reliability characteristics of shelter systems as specified in requirements documents. It does not cover special testing such as sound level, ventilation, etc., governed by separate TOPs. This document does not impose design specifications; rather, it describes tailored processes that result in realistic test methods based on materiel system performance requirements. The focus pertains only to those levels of testing appropriate for military shelter systems and considers test levels neither too high nor too low but based on the environments that the shelter systems will be deployed in throughout their service life.

Shelter systems encompass tactical shelters, non-tactical shelters, cargo bed covers (CBC), and camouflage nets. Tactical shelter systems are highly mobile, transportable structures designed for a functional requirement that provides a live-in/work capability. These structures can be rigid wall shelters, soft wall shelters, or hybrid shelters. Rigid wall shelters are pre-sized non-expandable or expandable shelters that are transportable by land, sea, or air. These shelters require minimal site preparation and no specialized setup. Soft wall shelters include air-supported and prefabricated structures that are transported and then erected or assembled on site. Hybrid shelters are a combination of rigid wall and soft wall shelters that are transported and erected or assembled on site. Non-tactical shelters are modular or prefabricated structures designed to be shipped to the operating location and assembled with external unit support. Non-tactical shelters include containers (e.g., MILVANs, CONEX containers) and refrigerated structures.

Shelters also include enclosures for computers, communications equipment, and other "permanently" mounted equipment not meant to be removed at destination. Shelters also encompass International Organization for Standardization (ISO) shipping containers modified or built to provide live-in and work-in capability or have permanently mounted equipment. CBCs provide a vented, weather-tight, and lockable rigid wall enclosure mounted to tactical wheeled vehicles and trailers to store, protect, and secure equipment, tools, and other theft-prone items. CBCs are designed not to interfere with the carrier's mobility by ground, air, or rail. Camouflage nets are screen systems used to conceal and sometimes cool tactical equipment in woodland/desert environments.

2. FACILITIES AND INSTRUMENTATION.

2.1 Facilities.

a. Rain Test Facility.

b. Environmental Test Facility.

c. Transportability Test Facility.

d. Electromagnetic Interference (EMI) Test Facility.

e. Areas capable of conducting Blackout, Sound, Sand and Dust tests.

2.2 Instrumentation.

2.2.1 Calibration.

All instruments used to monitor or control test parameters must be calibrated for accuracy. Generally, instruments should be checked prior to and after each test. Calibration intervals must meet the guidelines of American National Standards Institute/National Conference of Standards Laboratories (ANSI/NCSL) standard Z540.3[1**] or ISO 10012[2]. All instruments and test equipment used in conducting the tests in this document must:

a. Be calibrated to laboratory standards, and be traceable to the National Standards via primary standards.

b. Have accuracy equal to at least one-third the tolerance of the variable to be measured. In the event of conflict between this accuracy and guidelines for accuracy in the test methods of this TOP, the TOP governs.

Instrument	Tolerance
Wind direction	±1°
Ambient wind velocity	±10% of specified value
Relative humidity	±5%
Ambient air temperature	±2 °C (±3.6 °F)
Test thermocouple temperature	±2 °C (±3.6 °F)
Total elapsed time	±1% of specified value.
Pressure	±5 percent of specified value or ±200 Pa, whichever is greater

Instrument	Requirement
Platform Scales	accuracy of 0.5 kg (1 lb)
Wind-producing machine	to maximum of 121 km/hr (75 mph)
Measuring tape	steel at least twice as long as the maximum dimension of test item
Stopwatch	± 1 second
Cameras/film	still and video

3. REQUIRED TEST CONDITIONS.

The sequence of test events must take into account the likelihood of damage to the test item during testing and the number of test items received; therefore, nondestructive test events should be conducted before destructive test events. For example, Blackout, Low Temperature, or High Temperature should be performed before Durability, Snow Load, or Blowing Rain Tests. If a test item is not mission-capable, no further testing will be conducted unless the item is repaired or replaced.

** Superscript numbers/letters correspond to those in Appendix D, References.

4. TEST PROCEDURES.

During each phase of the test, test samples of three should be used, if possible.

4.1 Initial Inspection.

The purpose of this test is to determine if the test item(s) is/are complete and ready for testing. The shelter system should be erected or set up in accordance with the Operator's Technical Manual (TM). The TM is normally supplied with the test item. If possible, set up the test item under standard ambient conditions to ensure that it is operating properly and to obtain baseline performance and background data.

a. Background data of each item:

(1) Item nomenclature, model, serial number, manufacturer, etc.

(2) Inventory of major components. Use sample list (Table 1) if an Inventory List is not provided.

(3) Environmental test history of the test item. Determine if the test item has been tested before.

TABLE 1. TEST ITEM INVENTORY LIST.

Test Project No_____ Item No._____

ITEM NO.	NOMENCLATURE	MODEL/SERIAL NO.	QTY	PHYSICAL APPEARANCE

b. Visually inspect the shipping package(s) and test item(s), and record the following:

(1) Any damage to the shipping package(s).

(2) Any damage to the test item or its accessory equipment including:

(a) Test item tears, broken accessories.

(b) Test item material deterioration.

(c) Manufacturing defects.

(d) Evidence and effects of moisture, spillage, mildew, or insect attack.

(e) Evidence of wear.

c. Compare the items received to the item inventory list. Record any shortages, such as:

(1) Missing accessories.

(2) Missing tools.

(3) Missing instructions.

(4) Missing components.

d. Photograph the following:

(1) Fully deployed shelter.

(2) Evidence of damage.

(3) Manufacturer's labels and instructions (safety (cautions, warnings, lifting), operating, maintenance, etc.) attached to the test item.

4.2 Safety and Health.

The purpose of this test is to determine any safety or health hazards associated with the test item. Safety assessment will focus on obvious hazards to the operator using the System Safety Verification Checklist in Appendix B.

a. The test item will be inspected as a system, and no disassembly of components or subsystems will be performed other than those specified as part of user-level maintenance. The observation of a potential hazard will be investigated to determine its severity, appropriate measurements will be taken to document the hazard, and avoidance procedures will be developed. The hazards will be classified in accordance with MIL-STD-882D[3], and risk level will be assigned. For risk levels above low (Figure 1), hazard avoidance procedures or control measures will be incorporated prior to continuation of testing.

b. Safety documents shall be reviewed to determine compliance to test and safety requirements. Safety documents include but are not limited to Safety Assessment Report (SAR), Health Hazard Assessment Reports (HHARs), and Material Safety Data Sheets (MSDS). Use TOP 10-2-508[4] as guidance. The safety inspection will focus on obvious hazards to the operator.

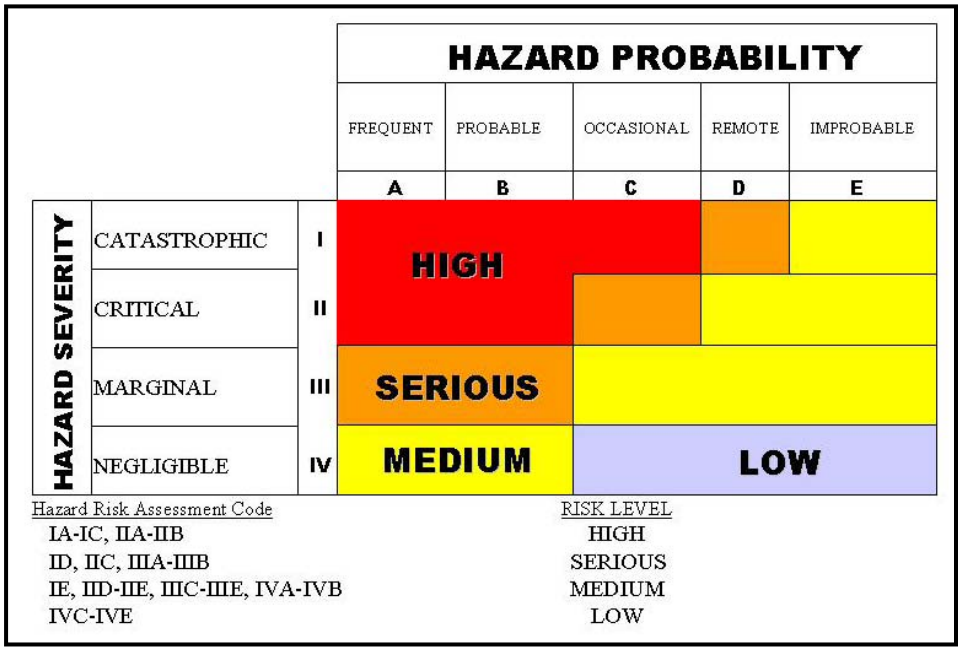

Figure 1. Hazard probability/severity chart.

4.2.1 Toxic Fumes.

Conduct toxic fumes test in accordance with TOP 02-2-614[5] to determine the levels of toxic substances produced by the test item during operation.

4.3 Physical Characteristics.

The purpose of this test is to determine physical characteristics, center of gravity (CG), and weight distribution of the test item as applicable. Testing is conducted in accordance with TOP 01-2-504[6]. Determine the following for the test item:

a. Test Item and Accessory Characteristics. Physical dimensions, including length and width or floor space; height of the roof at all significant points; internal volume; height, width, type, and number of operational doors, personnel doors, and windows; and size, location, dimensions, and number of heater duct openings, vents, and other designed openings.

b. Material physical and chemical characteristics.

c. Transportability interface.

d. Interoperability and interface requirements.

4.4 Blackout/Near Infrared (NIR) Detectability.

The purpose of this test is to determine if the test item can prevent detectable light leakage when viewed with the naked eye and with Night Vision Goggles (NVG).

a. Erect or set up the shelter in accordance with the Operator's TM. The test area must be capable of accommodating the deployed test item with no visual obstructions within a 300-m (984-ft) radius around the entire test item.

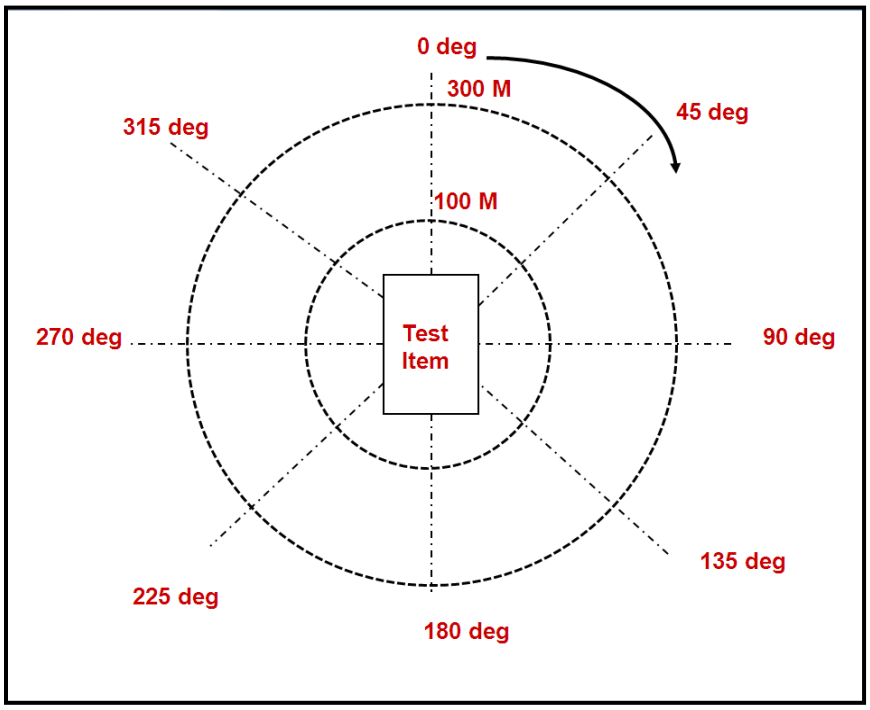

Figure 2. Blackout test setup.

b. Markers will be deployed along two concentric circles at 45 degree increments around the test item at distances of 100 and 300 m (328 and 984 ft) from the test item's center point (see Figure 2).

c. Blackout/NIR Detectability testing shall be conducted on a moonless night at the end of astronomical twilight. Astronomical twilight is the time when the sun is below the horizon such that the sky is no longer illuminated by the sun, and it is dark enough for all observations. Moon rise/set and astronomical twilight hours are obtained from Naval Meteorology and Oceanography Command official website: http://aa.usno.navy.mil/data/docs/RS_OneYear.php. For example, on 21 January 2010, the moon sets at 1302 hours and astronomical twilight ends at 1847 hours. Therefore, Blackout/NIR Detectability testing should start at approximately 1848 hours (see sample charts in Appendix C). The following shall be performed:

(1) The lights supplied with test item (or fluorescent lights meeting MIL-L-44259C[7] or a 100-watt incandescent lamp) will be positioned as described in the Operator's TM. If no procedure is described in the TM, each light shall be placed anywhere in a plane 0.6 m (2 ft) from one inside end wall and every 2.7 m (9 ft) of floor space along the center of the test item.

(2) Good communication must be established between the test personnel instructing the observers and the test personnel who turns the light on and off inside the test item.

(3) For blackout testing at 100 m (328 ft) with the naked eye, five observers will first be dark adapted for at least 30 minutes. Observers will be placed in a completely dark area for the entire 30 minutes until instructed by test personnel to commence testing. If observers' sight becomes compromised from exposure to a light source in the immediate area, they must be re-adapted for an additional 30 minutes.

(4) Following dark adaptation, conduct baseline light detection test for each observer to determine if observer can see light leakage with naked eye from the test item during the actual test conduct. For example, starting at the zero marker at 100 m, when instructed, each of the five observers shall observe low intensity light source emitted by one personnel outside the test item. Light source could be blackout light from an HMMWV or any other low intensity or blackout light available.

(5) The five observers will then traverse the 100-m (328-ft) circle starting at the zero marker and then to each 45 degree marker. When instructed by the test personnel, each of the five observers will view the test item with the naked eye from each 45 degree marker. Observation will be done separately in a predetermined trial sequence as shown in Table 2. Each observer trial sequence will be under two conditions, one with the light inside the test item turned on and one with the light turned off.

TABLE 2. OBSERVER TRIAL SEQUENCE.

Trial No.	View Angle, deg	Light Sequence	Natural Eye, % of Observers 100 m (328 ft)	NVG, % of Observers 300 m (984 ft)
1	0	On		
2		Off		
3	45	Off		
4		On		
5	90	Off		
6		On		
7	135	On		
8		Off		
9	180	On		
10		Off		
11	225	Off		
12		On		
13	270	On		
14		Off		
15	315	On		
16		Off		

(6) Test personnel will record whether there is light leakage or no leakage for each observer response at each 45 degree marker. If light leakage is determined to be the result of improper test item setup, correct the problem and repeat the test.

(7) For NIR detectability testing at 300 m (984 ft) with NVG, three observers will traverse the 300-m circle from the test item starting at the zero marker and moving to each 45 degree marker, observing the test item with NVG. Each observer will be asked if light is visible from the test item (each observer must remain unaware of the others' answers). Each observer shall view the test item in a predetermined trial sequence as shown in Table 2.

(8) Test personnel will record whether there is light leakage or no leakage (as observed with NVG) for each observer response at each 45 degree marker.

(9) Photograph the test item with a camera coupled with an Image Intensifier at each 45 degree marker along the 300-m (984-ft) circle according to the predetermined test sequence (see example in Figure 3). The Test Officer will compare the photographs to the observer comments.

d. For blackout testing under ingress/egress conditions, erect the test item in accordance with the Operator's TM with the vestibule facing the zero marker. Repeat step (4) from the zero marker while one observer enters the test item through the doorway at the vestibule and while the observer leaves the test item through the doorway at the vestibule.

e. Present the data in terms of percent correct response relative to distance and viewing angle (see Table 2).

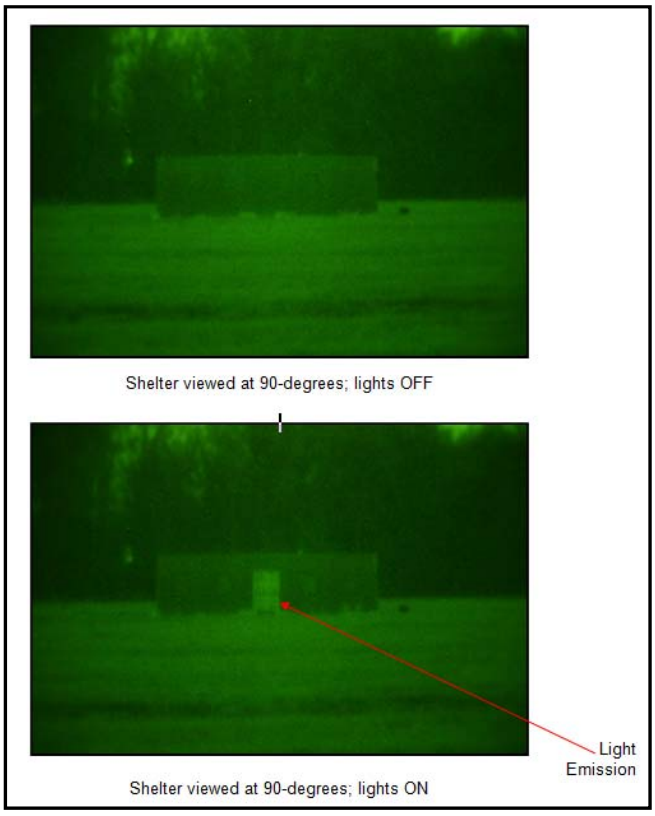

Figure 3. Examples of Blackout test photographs, one with light emission.

4.5 Roof Load.

4.5.1 The purpose of this test is to determine the degree to which the test item can withstand a roof load without sustaining damages. Roof load includes snow load on soft wall shelters and rigid wall shelters and personnel load on rigid wall shelters.

a. Roof load testing shall be performed in accordance with Army Regulation (AR) 70-38[8], and American Society for Testing and Materials (ASTM) E 1925-04[9]. Roof load test procedures herein pertain to three types of structures: rigid wall shelters, soft wall shelters, and hybrid shelters.

b. The extent of roof load testing will take into account only the roof surface area that collects snow.

(1) Rigid Wall. Rigid wall shelters are typically certified ISO containers. These systems can be configured several ways depending on the requirements. Some rigid wall shelters, such as the type shown in Figure 4, have the assembled expansion unit slide out of each side of the container. In containers such as the type shown in Figure 5, walls fold down to expand floor space; panels are then erected to enclose the expansions and make the structure rigid. For testing purposes, rigid wall shelters must meet two criteria: snow load and personnel load. The time duration for both snow load and personnel load is 5 minutes.

Figure 4. Two-sided medical operating room with rigid walls and expandable floors.

Figure 5. Two-sided semi-integrated ISO shelter with rigid fold-down walls.

TABLE 3. LOAD SPECIFICATIONS[a] FOR SHELTER SYSTEMS.

	RIGID WALL SNOW LOAD		RIGID WALL PERSONNEL LOAD		SOFT WALL SNOW LOAD	
	kg/m^2	lb/ft^2	kg/m^2	lb/ft^2	kg/m^2	lb/ft^2
Specification	195	40	300	660	49	10

[a]Load specifications could be less based on ASTM E 1925-04.

(2) Soft wall. The shape of the roof of a soft wall shelter will be used to determine the area of the roof to be used for roof load testing. The roof snow load criterion of 49 kg/m^2 (10 lb/ft^2) is equivalent to a depth of 0.5 m (20 in.) of snow with a specific gravity of 0.1 and represents a snowfall of less than 24 hours. Soft wall shelters must withstand a snow load for 12 hours.

(3) Hybrid. Hybrid shelter systems are a combination of rigid wall and soft wall shelters. Hybrid shelters typically have walls that fold down to form the expansion floor and soft covering to form the expansion walls, such as the one shown in Figure 6. The roof surface area for rigid wall sections must withstand a snow load of 195 kg/m^2 (40 lb/ft^2) and a personnel load of 299 kg (660 lb) for 5 minutes. The soft wall section must withstand a snow load of 49 kg/m^2 (10 lb/ft^2) for 12 hours.

Figure 6. Hybrid shelter with rigid walls and soft fold-down walls.

c. Snow Load Calculations. Snow load calculations take into account the shape of the roof area under test. Regardless of shape and architecture, loads acting on a roof sloped up to and including 70 degrees will be assumed to act on the horizontal projection of the roof (Figure 7). If the roof slope angle exceeds 70 degrees, the roof will be considered free of snow, and no snow load testing should be conducted.

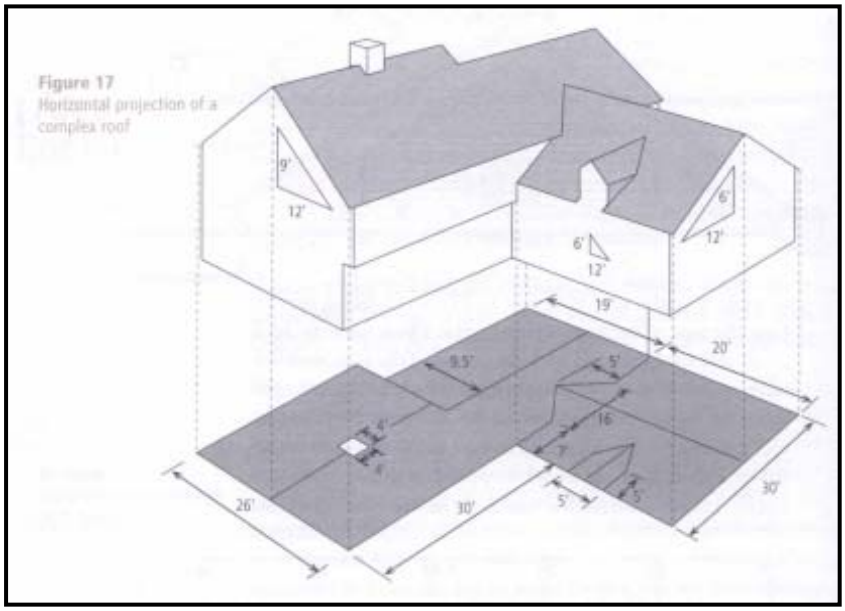

Figure 7. Horizontal projection of sloped roof.

4.5.2 Pretest.

a. Erect the test item in accordance with the Operator's TM.

b. Collect pretest data on the functional parameters that will be monitored during and after the test event. For each test item, document roof height before the test, after roof loading, and after the test, and include roof deflection data in the test report. See Table 4 for a sample display of this data. Record the test history of test item and report whether prior tests may have influenced the results of the roof load test.

TABLE 4. ROOF HEIGHT MEASUREMENT DATA.

PRE-TEST HEIGHT		HEIGHT AFTER LOAD IS APPLIED		POST-TEST HEIGHT AFTER 12 HRS		HEIGHT AFTER LOAD IS REMOVED	
cm	in.	cm	in.	cm	in.	cm	in.

c. Snow Weight Calculations. To determine how much weight to apply to the roof, use the following calculations:

(1) Rigid wall and soft wall calculations:

Area (m^2 or ft^2) = LxW
Load = (kg/m^2 or lb/ft^2)
Total Snow Weight (kg or lb) = Area (m^2 or ft^2) x Load (kg/m^2 or lb/ft^2)

(2) Soft wall shelters with sloped roofs. Calculate the projected roof area by multiplying the length (L) times the width (W) (Figure 8).

(3) Soft wall shelters with arched roofs. The roof load area is the arc length formed by the projected angle (Θ) for roof arcs where snow accumulates, i.e., 70 degrees and length L. This arc length (S), is a measure of the height (H) of the arc times the projected angle (70°) in radians (Figure 9). Therefore,

S (m or ft) = HΘ
Arched Roof Area (m^2 or ft^2) = SxL
Total Snow Weight (arched roof) (kg or lb) = Roof Area (m^2 or ft^2) x Load (kg/m^2 or lb/ft^2)

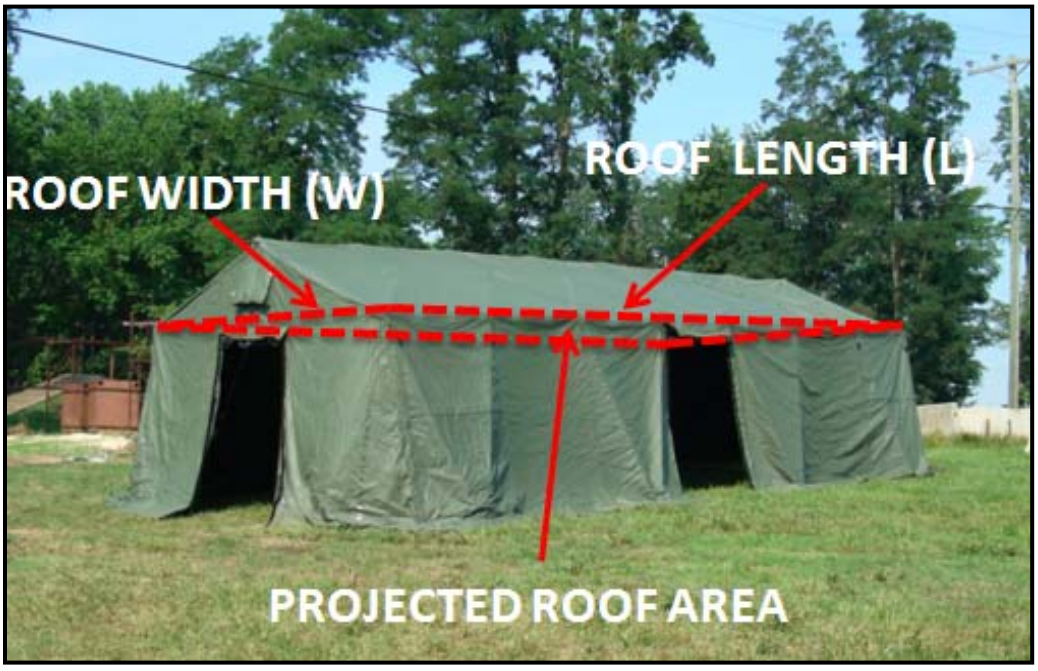

Figure 8. Projected roof area for sloped soft wall tent.

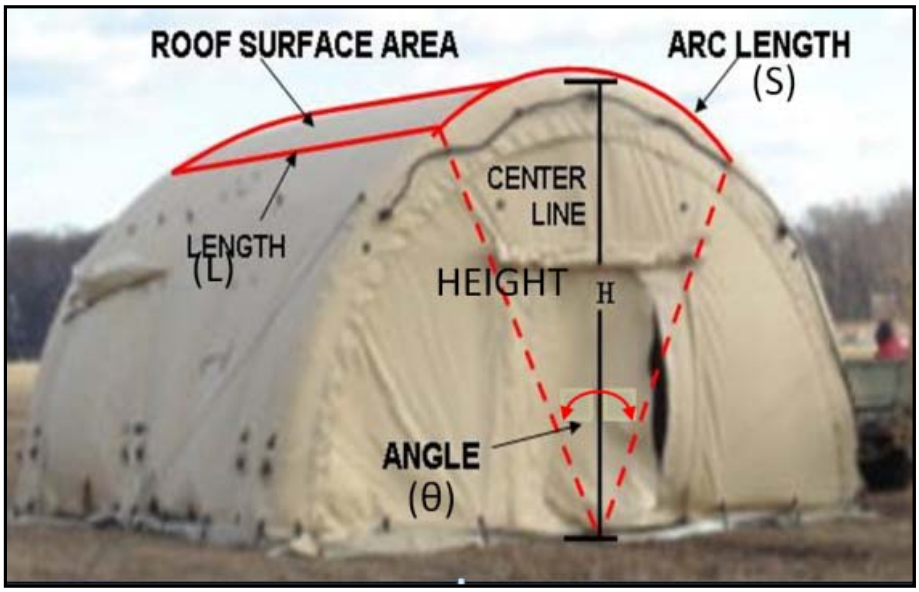

Figure 9. Projected snow load roof area for arched soft wall tent.

4.5.3 Test Conduct.

a. Rigid Wall Shelter.

(1) Simulated Snow Load. The shelter will be subjected to a uniform simulated snow load equivalent to 195 kg/m^2 (40 lb/ft^2). Apply the simulated snow load to the measured roof area by using a sheet of steel plate that matches the size of the roof area (e.g., two 2.4 x 3 m (8 x 10 ft) sheets side by side in the case of a 2.4 x 6 m (8 x 20 ft) ISO container). The thickness of the steel sheet is calculated by first finding the container roof surface area. The surface area multiplied by the snow load requirement of 195 kg/m^2 (40 lb/ft^2) yields the total weight. Load the fixed and folding roof areas for 300 seconds (5 minutes), then remove the weight and visually inspect the structure for any evidence of structural damage, delamination, permanently popped seals, panel separation, etc.

(2) Simulated Personnel Load. Both fixed and folding roofs (see Figures 4 and 5) shall be subjected to a personnel load of 300 kg (660 lb) (e.g., a 3- x 6-m (1- x 2-ft) sheet of steel 20 cm (7.8 in.) thick with a density of 7753 kg/m^3 (484 lb/ft^3). Place the steel sheet over the weakest points of the test item for a period not exceeding 300 seconds (5 minutes). The weakest points on the roof are generally away from the frame, at the middle of the roof, or at the horizontal joints.

(3) Upon completing the test, inspect the for any evidence of structural damage, delamination, permanently popped seals, panel separation, etc.

(4) Record discrepancies and take photographs.

b. Soft Wall Shelter.

(1) Prior to testing, conduct a visual inspection and note any damage that needs repair prior to applying the simulated snow load. When making repairs, use only items from the repair kit provided with the test item.

(2) Measure and record the roof height before applying the simulated snow load to determine roof deflection at the end of the test period. This measurement can be taken by mounting a tape measure inside the shelter at the center of the frame support member along the longitudinal axis of the shelter.

(3) Apply the simulated snow load to the roof area of the test item designated for loading using 2.7 x 5.5 m (9 x 18 ft), 0.6-kg/m^2 (18-oz./yd^2) vinyl sheets, which weigh 9.5 kg (21 lb) each (Figure 10).

$$\text{\# of vinyl sheets} = \frac{\text{Total Snow Weight (kg or lb)}}{\text{9.5 kg or 21 lb/sheet}}$$

Figure 10. Snow load test of framed tent

(4) Gradually apply the load, longitudinally centered, to the roof surface so that the area covered equals the horizontal projection of the roof. Look for damages as the load is being applied. Record damage or discrepancies.

(5) After the load is applied, record the deflection measurement from the tape measure and allow the shelter to rest for at least 12 hours.

(6) Use a video recorder to capture any failure that may occur during the test period.

(7) After the test period, record the final deflection from the tape measure then gradually remove the simulated snow load from the shelter.

(8) Inspect the shelter for damages, and record evidence of structural damage, seam separation, or fabric damage.

(9) Determine if there is permanent deformation of the frame member from which the tape measure is suspended. Permanent deformation is calculated as follows:

Permanent Deformation = Pre-Test Height (cm or in.) – Height After Load is Removed (cm or in.)

c. Hybrid Shelter. Follow procedures 4.5.3a and 4.5.3b above for rigid wall and soft wall sections as applicable.

4.6 Durability.

The purpose of this test is to determine the durability characteristics of the shelter. Durability testing of shelter systems consists of two phases: erect and strike of the shelter on level ground with no precipitation, with wind speed not to exceed 24 km/hr (15 mph), and with an ambient temperature no lower than 4 °C (40 °F). One cycle consists of one erect and one strike. The number of erect-strike cycles depends on the life cycle of the test item (default is 50 cycles). Inspect the test item for damages after each erection cycle.

4.6.1 Erection.

Starting with the test item packed for transport and on the ground, erect the test item as specified in the Operator's TM and record the following:

a. Test site wind velocity and temperature.

b. Time required, as applicable:

(1) To unpack the item.

(2) To assemble the test item.

(3) To assemble the vestibule.

(4) To anchor the test item.

(5) To install accessory equipment.

(6) To complete system erection (from start of unpacking to ready for use).

c. Difficulties encountered, as applicable:

(1) Unpacking the test item.

(2) Assembling the test item.

(3) Anchoring the test item.

(4) Installing accessory equipment.

(5) Opening or closing doors.

(6) Other difficulties during setup.

d. List accessory equipment installed.

e. Determine adequacy of TM or instruction manual.

f. Determine adequacy of supplied tools.

g. List additional tools required, if any.

h. Determine training required.

4.6.2 Striking.

Strike the test item as specified in the Operator's TM and record the following:

a. Test site wind velocity and temperature.

b. Time required, as applicable:

(1) To remove accessory equipment.

(2) To disassemble the vestibule.

(3) To disassemble the frame.

(4) To pack the test item for transport.

(5) To complete system striking (from start of accessory equipment removal to ready for transport).

c. Difficulties encountered, as applicable:

(1) Removing accessory equipment.

(2) Disassembling the vestibule.

(3) Disassembling the frame.

(4) Removing the anchoring stakes from the ground.

(5) Packing the test item for transport.

4.6.3 Crew Size.

a. Determine the time required to erect and strike each test item when applicable by averaging the times required by the crew size specified in the TM.

b. If the test seeks to determine the optimum crew size, conduct the number of strike-erect events with crews of specified sizes while holding the crew size constant for the duration of the test. Record the crew size with the lowest average time as the maximum crew required to erect and strike the shelter. Record the smallest crew that can successfully erect and strike the shelter as the minimum crew size. The optimum crew size will normally be between the minimum and maximum crew sizes. Determine the optimum crew size by evaluating the performance of individual crew members and by evaluating the data for all crews. The optimum time required will be the average time required for the optimum crew size.

4.7 EMI.

EMI testing must be conducted in accordance with Military Standard (MIL-STD) 461[10] and TOP 1-2-511[11] as applicable.

4.8 Transportability.

Testing must be performed as described in MIL-STD-810[12], TOP 01-2-500[13], and TOP 01-2-501[14] as applicable.

a. Sling and Tie-down Attachments. The objective of this test is to determine if sling and tie-down attachments comply with dimensional/directional limits and design, positioning, and strength requirements for transportability.

b. Rail Transportability. The objective of this test is to determine if the test item meets the specified requirements for rail transportability certification by assessing the structural integrity of the test item and the adequacy of the tie-down system and tie-down procedures.

c. Road Transportability. The objective of this test is to determine if the test item can be transported on and off highways.

d. Air Transportability – Fixed Wing Internal. The objective of this test is to determine the suitability of the test item to be transported by U.S. Air Force (USAF) and Civil Reserve Air Fleet (CRAF) fixed-wing aircraft.

e. Air Transportability – Rotary Wing Internal. The objective of this test is to determine the capability of the test item to be transported in an internal configuration by rotary-wing aircraft.

f. Air Transportability – Rotary Wing External. The objective of this test is to determine the capability of the test item to be transported in an external configuration by rotary-wing aircraft.

g. Air Transportability – Airdropped Materiel. The objective of this test is to determine the suitability of the test item to be airdropped from fixed-wing aircraft.

h. Vibration Shaker Table. The objective of this test is to determine if the test item and associated components can withstand the transportation environment associated with delivery during deployment.

i. Shock/Transit Drop. The objective of this test is to assess the structural integrity and impact resistance of the test item during transport.

4.9 Environmental.

The applicable environmental tests, such as solar radiation, humidity, and salt fog shall be performed as described in MIL-STD-810. In addition, the following wind, rain, temperature, sand, and dust tests are required to be performed as described in this TOP.

4.9.1 Wind.

The purpose of this test is to determine if the unoccupied test item can withstand wind without sustaining damage.

4.9.1.1 Steady Wind.

Determine the effects of a continuous wind as applicable:

a. Erect the test item in accordance with the Operator's TM. Position the wind machine perpendicular to the side of the shelter that will be tested. The wind machine must be at a distance of 6 m (20 ft) from the side of the shelter or an appropriate distance to achieve the desired wind speed. In general, use one wind machine for every 5 m (16 ft) length of shelter side to be tested (Figure 11).

b. Subject the side of the test item containing the primary entrance to winds of 88.5 km/hr (55 mph) for 30 minutes. Record any damage incurred.

c. Apply winds at 88.5 km/hr (55 mph) for 30 minutes on a single side 90° adjacent to the test item side of step b. Record any damage incurred.

d. Repeat steps b and c as applicable with the wind applied on the corner formed by the sides of step b and step c.

4.9.1.2 Gust Tests.

Determine the effects of wind gusts as follows:

a. Erect the test item in accordance with the Operator's TM.

b. Subject the side of the test item containing the primary entrance to three continuous wind gusts of 105 km/hr (65 mph) for 10 seconds each during the 30-minute duration specified in 4.9.1.1.

c. Repeat steps a and b with the wind applied on the side of the item 90° adjacent to the test item side with the primary entrance.

d. Repeat steps b through c with the wind applied to the corner formed by the sides of step b and step c.

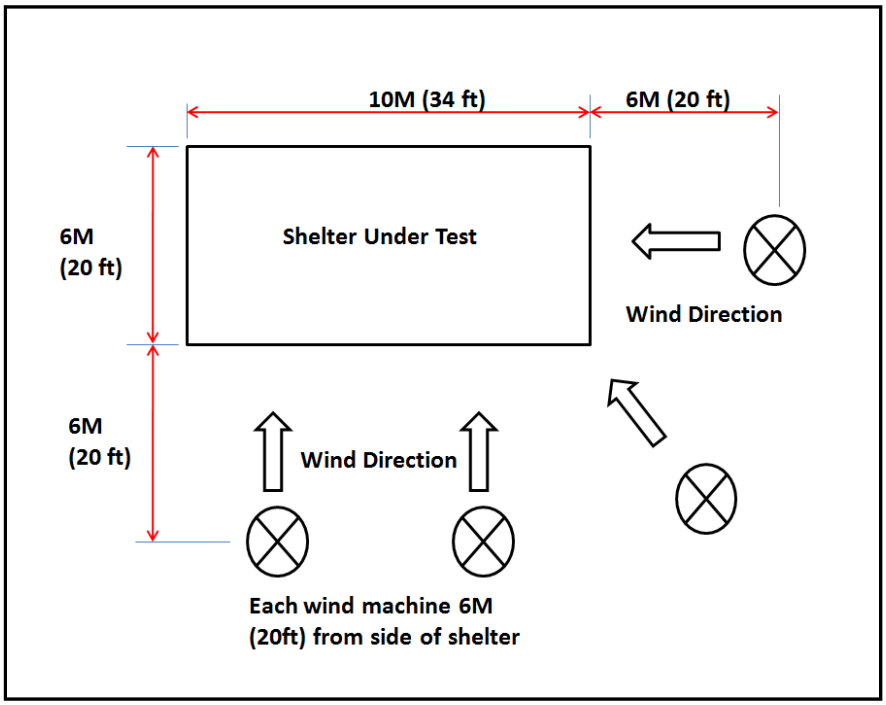

Figure 11. Wind and Blowing Rain test setup.

4.9.2 Rain.

The purpose of this test is to determine if the unoccupied test item can withstand rain without leaking or sustaining damage:

4.9.2.1 Steady Rain.

Determine the effects of steady rain as follows:

a. Erect the test item in accordance with the Operator's TM.

b. Subject the test item to rainfall rate of 4 in/hr (10 cm/hr) for 30 minutes or as described in the Detailed Test Plan (DTP).

c. Inspect inside the test item for water intrusion. Record any water intrusion incurred and the probable point of entry. Intrusion (leakage) is defined as follows:

Negligible – damp spots, barely noticeable.

Minor – droplets forming on the fabric or at the seams, but not falling under ordinary circumstances in a way to impair the intended use of the shelter.

Major – water continually leaking and dropping off or running down the item's inner surface in a way that impairs the intended military use.

4.9.2.2 Wind-Driven Rain.

Determine the effects of wind-driven rain on the test item as follows:

a. Erect the test item in accordance with the Operator's TM. Position the wind machine as described in 4.9.1.1.

b. Subject the test item to rainfall rate of 5 cm (2 in.) per hour.

c. Apply winds at 88.5 km/hr (55 mph) for 30 minutes.

d. Subject the side of the test item being tested to three continuous wind gusts of 105 km/hr (65 mph) for 10 seconds during the 30 minutes.

e. Inspect the test item for leakage or damage. Inspect inside the test item for water intrusion. Record any water intrusion incurred and the probable point of entry.

f. Repeat steps b through e for the side 90° adjacent to the side tested in step c as applicable.

4.9.2.3 Water Spray.

Testing shall be conducted in accordance with MIL-STD-810, Procedure II. The purpose of this test is to determine if the test item can withstand water sprayed against the test surface without leaking or sustaining damage. The pressure of the water spray shall be determined from the requirements or at a minimum rate of 276 kPa (40 psi). A 276-kPa nozzle pressure should produce water droplets traveling at approximately 64 km/hr (40 mph).

Conduct the following as applicable:

a. Set up the test item in accordance with the Operator's TM under the rain fixture.

b. Position the nozzles of the rain fixture 48 cm (19 in.) from the side to be tested.

c. Spray water onto the test surface and adjust pressure gauge such the water pressure is 276 kPa. Spray the test item for 40 minutes.

d. After the 40-minute spray period, inspect the interior of the test item for water intrusion.

e. Repeat steps b, c, and d for each successive side to be tested.

f. Estimate and record the volume of any infiltrated water and the probable point of entry.

g. Perform operational check if applicable.

h. Inspect the test item for the following if applicable and record any discrepancies:

(1) Physical damage.

(2) Permanent deformation.

(3) Delamination.

(4) Seal separation.

(5) Degraded operation.

(6) Photograph any damages.

4.9.3 High/Low Temperature Storage and Operation.

Conduct testing in accordance with MIL-STD-810, Test Methods 501 and 502. If applicable, conduct the heat retention test described below in addition.

4.9.3.1 Heat Retention Test.

Conduct heat retention tests to determine heat retention capability of the test items.

a. Erect the test item(s) in environmental test chamber in accordance with the Operator's TM.

b. Before all tests, inspect all components for serviceability.

c. Install instrumentation and allow it to stabilize as applicable.

(1) For example, in a shelter with a rectangular footprint, install thermocouple racks every 2.8 m (9 ft) as illustrated in Figure 12.

(2) The number of thermocouple stands will depend on the area of the footprint. Position the thermocouples at head, hand, and knee locations as shown in Figure 13.

d. Close all vents, windows, and doors.

e. Lower chamber temperature according to the test requirements.

f. Upon achieving a stable temperature at head, hand, and knee positions, turn on heaters and allow them to run until the required hand-level temperature stabilizes. Temperature stabilization is attained when the temperature in the test item is considered to have the longest thermal lag and is changing at a rate of no more than 2.0 °C (3.6 °F) per hour.

g. Upon achieving a stable hand-level temperature, turn off the heaters. Monitor temperatures at 1-minute intervals to ensure enough data is collected for comparison to other test items.

h. Use temperatures at hand level to determine cool-off time. Terminate the test when the hand level temperature stabilizes (15 minutes of consecutive temperature, or after 1 hour has elapsed).

i. Compare all data points to determine heat retention of each test item.

j. Use temperature categories C1 and C2 as outlined in MIL-STD 810, Table C-I, whenever possible.

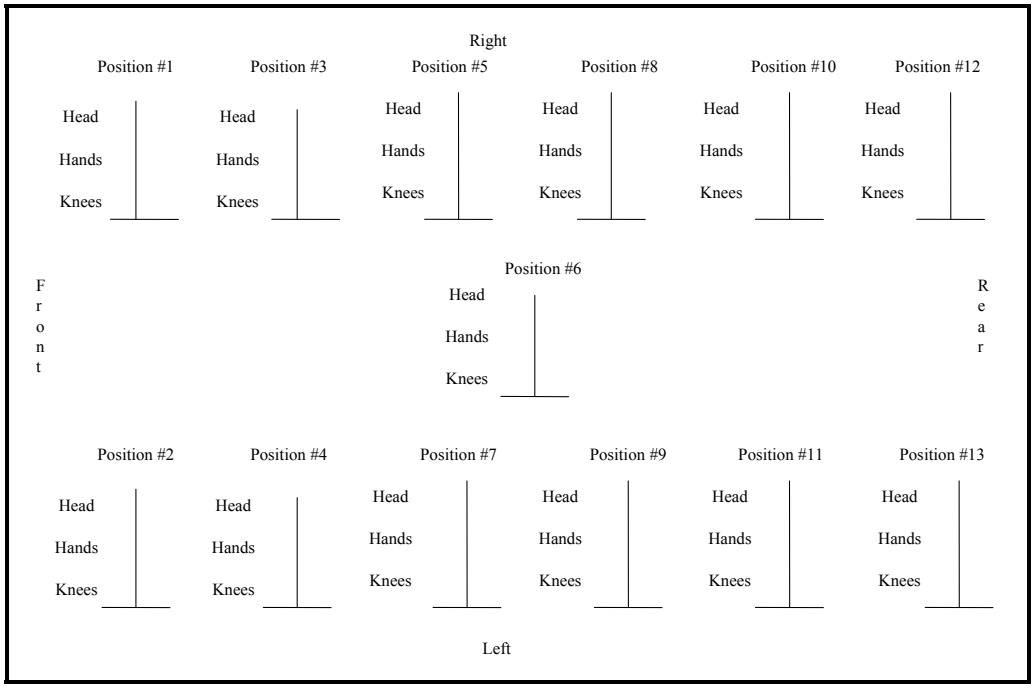

Figure 12. Thermocouple locations in rectangular shelter.

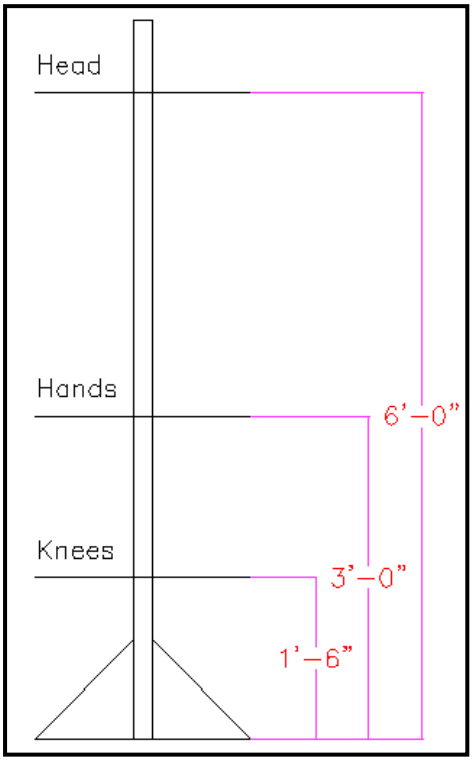

Figure 13. Thermocouple temperature sensing locations.

4.9.4 Blowing Sand or Dust.

Conduct blowing sand and dust tests to determine if the test item can resist penetration of blowing sand or dust in accordance with TOP 01-2-621[15].

4.10 Human Factors Engineering (HFE).

Conduct HFE tests and considerations in accordance with TOP 01-2-610[16].

a. Lighting. The purpose of this test is to assess the adequacy of workspace lighting. The procedure is primarily intended for internal enclosures but can be extended to external work sites to the degree that requirements for external lighting are consistent with those for internal illumination.

b. Noise Measurement. The purpose of this test is to determine if noise levels produced by an item (or components of that item) under test present hazards to personnel, or if they meet aural non-detectabillty criteria, speech intelligibility considerations or contribute to community annoyance.

c. Temperature, Humidity, and Ventilation Measurements. The purpose of this test is to evaluate temperature, humidity, and ventilation of enclosed areas that have controls for these environmental factors, with the exception of Wet Bulb Global Temperature (WBGT), which applies to the outdoor environment and to enclosed areas without any means to control these environmental factors.

4.11 Reliability, Availability, and Maintainability (RAM).

Conduct testing in accordance with TOP 01-1-030[17]. During all testing, record the following:

a. Scheduled maintenance as directed by the Operator's TM.

b. Equipment deficiencies and possible causes.

c. Adequacy of the interchangeability of parts for replacement operations.

d. Adequacy/accuracy of the technical and maintenance instructions provided in the Operator's TMs.

4.12 Final Inspection.

The purpose of this test is to determine if the test item is complete and ready for shipping.

a. Visually inspect the test item for previously unreported physical damages that may have occurred during testing.

b. Inventory major components.

c. Photograph and document any such damage.

5. DATA REQUIRED.

5.1 Initial Inspection.

a. Background data of each item:

(1) Item nomenclature, model, serial number, manufacturer, etc.

(2) Inventory of major components. Use sample list (Table 1) if an Inventory List is not provided.

(3) Environmental test history of the test item. Has the test item been tested before?

b. Visually inspect the shipping package(s) and test item, and record the following:

(1) Any damage to the shipping package(s).

(2) Any damage to the test item or its accessory equipment including:

(a) Test item tears, broken accessories.

(b) Test item material deterioration.

(c) Manufacturing defects.

(d) Effects of moisture, spillage, mildew, or insect attack.

(e) Evidence of wear.

c. Shortages, such as:

(1) Missing accessories.

(2) Missing tools.

(3) Missing instructions.

(4) Missing components.

d. Photograph the following:

(1) Fully deployed shelter.

(2) Evidence of damage.

(3) Manufacturer's labels and instructions (safety (cautions, warnings, lifting), operation, maintenance, etc.) attached to the test item.

5.2 Safety/Health.

Record data as described in TOP 10-2-508:

a. Results of safety inspection and associated Risk Assessment Codes (RACs) (see Figure 1).

b. Mitigations and modifications, if any.

5.2.1 Toxic Fumes.

Record data as described in TOP 02-2-614:

a. Peak, stabilized concentrations, and times for each gas as indicated in the DTP.

b. Atmospheric conditions including temperature and relative humidity.

c. Time duration of tests.

d. Details of test conditions.

e. Sampling probe(s), analyzer types, model serial numbers, calibration dates and manufacturer.

f. Type of calibration gases used, manufacturer, lot number and concentration.

5.3 Physical Characteristics.

Record data as applicable:

a. Results of test item characteristics.

b. Results of material physical and chemical characteristics.

c. Results of transportability interface.

d. Results of interoperability and interface requirements.

e. Coding and legibility (clear, unclear).

f. Coding:

(1) Manufacturer's name.

(2) Number and date of contract.

(3) Date of manufacture.

(4) Type of shelter.

Note: When conducting competitive testing, adding the manufacturers' names will restrict distribution of the document to For Official Use Only (FOUO).

g. Damage:

(1) To shipping packages.

(2) To test item/accessories.

h. Photograph the following:

(1) Evidence of damage.

(2) Manufacturer labels.

5.4 Blackout/NIR.

Record the following for each test item:

a. Test item identification number (TIIN).

b. Test site terrain (turf, rock, etc.).

c. Observer number (5 or 3, etc.).

d. Distance and marker at which light can be observed (100 m, 300 m).

e. Photograph of test item at each 45-degree marker.

f. Results of light leakage from ingress/egress tests.

g. Results of visual acuity test.

h. Results from luminance measurement.

i. Photograph of light locations.

5.5 Roof Load.

Record the following data as applicable:

a. Initial height before applying weight.

b. Roof height after applying weight (initial deflection).

c. Roof height after 12 hr test period (total deflection).

d. Roof height after load is removed (deformation).

e. Any physical damage observed.

f. Photographs/video of test item.

g. Total weight applied (all calculations).

5.6 Durability.

For each test item, record:

a. TIIN.

b. Test site terrain (turf, sand, etc.).

c. Ambient temperature and wind velocity.

d. Test site weather conditions (clear, rain, snow, etc.).

e. Test site terrain condition (wet, frozen, dry, etc.).

f. Handwear used (gloves, arctic mittens, none).

g. Evidence of wear.

h. Photographs of any damages.

5.6.1 Erection.

For each erection, record:

a. Test site wind velocity and temperature.

b. Difficulties encountered, as applicable:

(1) Unpacking the test item.

(2) Assembling the frame.

(3) Anchoring the test item.

(4) Assembling the vestibule.

(5) Installing accessory equipment.

c. Time required in minutes, as applicable:

(1) To unpack the test item.

(2) To assemble the frame.

(3) To assemble the vestibule.

(4) To anchor the test item.

(5) To install accessory equipment.

(6) For complete assembly.

d. List accessory equipment installed (light fixtures, desks, tables, etc.).

e. Determine adequacy of TM or instruction manual.

f. Determine adequacy of supplied tools.

g. List additional tools required (ladders, etc.).

5.6.2 Striking.

For each strike, record:

a. Test site wind velocity and temperature.

b. Time required in minutes, as applicable:

(1) To remove accessory equipment.

(2) To disassemble the vestibule.

(3) To disassemble the frame.

(4) To remove the anchoring stakes.

(5) For complete striking.

c. Difficulties encountered, if applicable:

(1) Removing accessory equipment.

(2) Disassembling the vestibule.

(3) Disassembling the frame.

(4) Removing the anchoring stakes.

(5) Packing the test item for transport.

d. Adequacy of TM or instruction manual.

e. Adequacy of supplied tools.

f. Additional tools required.

5.6.3 Adequacy of Crew Size.

a. Record the crew size recommend in the test plan.

b. Determine adequacy of crew size (enough, too many, too few).

c. Time for each erect/strike cycle.

d. Average time for 5.6.3c.

e. Smallest crew size that can erect/strike the shelter within a given time.

5.7 EMI.

Refer to TOP 01-2-511. For each test item as applicable, record:

a. Test item identification number.

b. Test site building number.

c. Baseline data functionality check.

d. Type of test, (i.e. Conducted Emissions (CE), Conducted Susceptibility (CS), Radiated Emissions (RE), and Radiated Susceptibility (RS)).

e. Test data (i.e. radiation levels, frequency) and compliance.

5.8 Transportability.

a. Refer to TOP 01-2-500 for data requirements for the following:

(1) Slinging and Tie-down Attachments.

(2) Rail Transportability.

(3) Road Transportability.

(4) Air Transportability – Fixed Wing Internal.

(5) Air Transportability – Rotary Wing Internal.

(6) Air Transportability – Rotary Wing External.

(7) Air Transportability – Airdropped Materiel.

b. Vibration Shaker Table. Refer to MIL-STD-810. Record the following as applicable:

(1) Pre-test operational check.

(2) Longitudinal test results.

(3) Transverse test results.

(4) Vertical test results.

(5) Post-test operational check.

(6) Record any physical damages.

(7) Photographs of physical damages.

(8) Vibration profiles used.

(9) Instrumentation used.

(10) Calibration dates of instrumentation.

c. Shock/Transit Drop. Refer to MIL-STD-810. Record the following as applicable:

(1) Pre-Test operational check.

(2) Number of drops.

(3) Height of drops.

(4) Description and photographs of any damage.

(5) Post-test operational check.

(6) Instrumentation used.

(7) Calibration dates of instrumentation.

5.8.1 Rail Impact.

Refer to TOP 01-2-501. Record the following as applicable:

a. Pre-test operational check.

b. Video of test item at 6.4, 9.6 and 13 km/hr speeds (4, 6 and 8 mph).

c. Desired and actual speed comparison.

d. Description and photographs of any damage.

e. Tie-down point locations on test item.

f. Post-test operational check.

g. Instrumentation used.

h. Calibration dates of instrumentation.

5.9 Environmental.

Refer to MIL-STD-810. Record the following as applicable:

a. Type of exposure (Hot, Cold, Wind, Rain, Blowing Sand/Dust, etc.).

b. Test temperatures.

c. Duration of exposure.

d. Test item configuration.

e. Critical item components.

f. Additional data to satisfy equipment specifications or requirements documents.

g. Temperature versus time plots.

h. Description and photographs of any damage that may occur.

i. Instrumentation used.

j. Calibration dates of instrumentation.

Note: For high/low temperature characteristics of each test item, average all readings for each thermocouple to determine the mean temperature of the test item at predetermined intervals. Average the mean temperatures for all test periods to determine the mean test temperature for the shelter. Compare the test results.

5.10 HFE.

Record data as described in TOP 01-2-610.

5.11 RAM.

Record data as described in Military Handbook (MIL-HDBK) 781[18].

a. For scheduled maintenance, record:

(1) Time of maintenance (day, month, year).

(2) Type of maintenance (weekly, monthly, etc.).

(3) Procedures performed.

(4) Equipment or material deficiencies and causes, if possible.

(5) Adequacy and accuracy of TM or maintenance instructions.

b. Describe any equipment deficiencies and possible causes.

c. Describe adequacy of the interchangeability of parts for replacement operations.

d. Describe inadequate or inaccurate technical or maintenance instructions in the TM.

5.12 Final Inspection.

Record the following as applicable:

a. Results of visual inspection.

b. Inventory of major test items.

c. Photographs of any damage.

6. PRESENTATION OF DATA.

a. Summarize and evaluate data obtained for each performance characteristic for each test item. Use appropriate charts, tables, and graphs to summarize test data. Give special consideration to any condition or circumstance that may have contributed to any test result.

b. When applicable, compare data for each performance specification with customer requirements to determine if the requirements were met/not met. Summary of test data, requirements, and any other pertinent information should be documented in the final report.

APPENDIX A. ABBREVIATIONS.

ANSI	American National Standards Institute
AR	Army Regulation
ASTM	American Society for Testing and Materials
ATC	U.S. Army Aberdeen Test Center
CBC	cargo bed cover
CE	conducted emissions
CG	center of gravity
CRAF	Civil Reserve Air Fleet
CS	conducted susceptibility
DTP	Detailed Test Plan
EMI	electromagnetic interference
FOUO	For Official Use Only
H	height
HFE	Human Factors Engineering
HHAR	Health Hazard Assessment Report
ISO	International Organization for Standardization
L	length
MIL-HDBK	Military Handbook
MIL-STD	Military Standard
MSDS	Material Safety Data Sheets
NCSL	National Conference of Standards Laboratories
NIR	near-infrared
NVG	night vision goggles
RAC	Risk Assessment Code
RAM	Reliability, Availability, and Maintainability
RE	radiated emissions
RS	radiated susceptibility
S	arc length
SAR	Safety Assessment Report
TIIN	test item identification
TM	Technical Manual
TOP	Test Operations Procedure
USAF	U.S. Air Force
W	width
WBGT	Wet Bulb Global Temperature

APPENDIX B. SYSTEM SAFETY VERIFICATION CHECKLIST.

ELECTRICAL SAFETY			
ISSUE	YES	NO	NA
1. Are operating personnel protected from accidental contact with voltages in excess of 30 volts?			
2. Does each contact, terminal, or like device, having voltages between 70 and 500 volts, rms or DC, with respect to ground, have barriers or guards to minimize accidental contact by operating or maintenance personnel?			
3. Are barriers or guards that protect terminals or like devices exhibiting 70-500 volts, clearly marked to indicate highest voltage encountered upon its removal?			
4. Are portions of assemblies operating at potentials above 500 volts, rms or DC, completely enclosed from the remainder of the assembly, and is the enclosure provided with non-bypassable interlocks?			
5. Are enclosures for potentials, which exceed 500 volts, marked "DANGER, HIGH VOLTAGE, XXX VOLTS", in white on a red background?			
6. Do all circuits and capacitors discharge to 30 volts or less within more than two seconds after power is removed?			
7. If the answer to question 6 is No, are the high-voltage capacitors or circuits automatically discharged when the case or rack is opened?			
8. Are test points provided in equipment where measurement of potentials in excess of 300 volts is required?			
9. Are test points designed to require plug-in, not clamp-on, test instruments?			
10. Are green indicator lamps provided to indicate "power on"?			
11. Is sufficient space provided between shield endings and exposed conductors to prevent shorting or arcing?			
12. Are electrical conductors designed to prevent insertion of the wrong plug into a receptacle or any other mating unit?			
13. Are plugs and receptacles coded and marked to clearly indicate mating connectors where those of similar configuration are in close proximity?			
14. Are plugs and receptacles designed to preclude electrical shock and burns while being disconnected?			
15. Are male plugs de-energized when disconnected?			
16. Are dissimilar plug/receptacle pairs used in units containing explosives?			
17. When equipment is designed to operate on more than one type of input power, does the connector design prevent connection or use of improper power?			
18. Are single-phase power cables properly color coded: black: hot, white: neutral, green: ground?			
19. Are three-phase power cables coded as in Question 18, above, with the second and third phases in red and blue, respectively?			
20. Are meter terminals protected from voltages of 70 volts or more?			
21. Do probes that are part of or accessories to the equipment contain safety guards that prevent contact with the tip and is the length of the exposed portion of the tip not more than 0.75 inches? (This question does not apply if the voltages to be measured are less than (a) 30 volts rms, (b) 60 volts DC, or (c) 24.8 volts DC interrupted at a rate of 10 Hz to 200 Hz.)			
22. Are current and voltage overload protection devices provided?			

ELECTRICAL SAFETY (CONT)			
ISSUE	YES	NO	NA
23. Except for antennas and transmission line terminals, are all external parts, surfaces, and shields at ground potential at all times?			
24. Is the path from the equipment to ground continuous and permanent?			
25. Is the ground wire color-coded green or green with yellow stripes?			
26. Does the ground have capacity to safely conduct any currents that might be imposed thereon?			
27. Is the ground wire separate from electrical circuits, i.e., not tied to neutral?			
28. Has a test been conducted to determine the amount of leakage current on the grounding conductor? If Yes, indicate the amount of current, in milliamperes, that was measured.			
29. Is the impedance of the path from the equipment tie point to ground sufficiently low to limit the potential drop and to allow the operation of overcurrent devices in the circuits?			
30. Does the path from the equipment tie point to ground have sufficient mechanical strength to minimize accidental ground disconnection?			
31. Is the ground connection to the chassis or frame secured by one of the following: spot welded terminal lug, soldering lug, screw, nut, and lockwasher?			
32. On transmitting equipment, is a grounding stud provided that permits attachment of a portable shorting rod?			
33. Except for radio frequency (RF) voltages, are antenna and transmission terminals at ground potential?			
34. Do convenience outlets automatically ground the mated plugs of metal-cased portable tools and equipment?			
35. Are both the phase and neutral supply voltage lines not connected to the chassis?			
36. Are wires and cables supported and terminated to prevent shock and fire?			
37. Are DC power connections color coded and marked for polarity?			
38. Does the main power switch cut off all power to the complete equipment?			
39. Is the main power switch clearly identified?			
40. Is the main power switch located on the front panel?			
41. Is physical protection provided from accidental contact with the power input side of the main power switch and the incoming power line connections?			
42. Are power switches located such that they cannot be operated by accidental contact?			
43. Are switches provided to deactivate mechanical drive units without disconnecting other parts of the equipment?			
44. Are means provided to cut off power while installing or replacing an item of equipment or an assembly or part thereof?			
45. Are emergency controls readily accessible and clearly identified?			
46. Does the equipment use batteries? If yes, indicate whether batteries are the primary or backup power source.			
47. Is the battery in the Government inventory? If yes, indicate the battery's nomenclature, e.g., BA-xxx, BB-xxx, etc.			
48. Can the battery enclosure or box prevent injury or damage in the event of a violent gas venting or rupture of the battery cells?			

49. Are battery compartments vented?			
MECHANICAL SAFETY HAZARD			
ISSUE	YES	NO	NA
1. Are safety covers provided for exposed gears, cams, levers, fans, and belts?			
2. Are self-locking or other fail-safe devices incorporated into expandable and collapsible structures, such as shelters, jacks, masts, and tripods, to prevent accidental or inadvertent collapsing or failing?			
3. Are positive means provided to prevent mismating of fittings; couplings; fuel, oil, hydraulic, and pneumatic lines; and mechanical linkages?			
4. Are doors and drawers and associated catches, hinges, supports, fasteners, and stops designed to prevent accidental injury?			
5. Is the installed equipment free of overhanging edges and corners that may cause injuries?			
6. Is the equipment likely to remain upright under normal use and in strong wind, considering its means of support and center of gravity?			
ENVIRONMENTAL SAFETY HAZARD			
ISSUE	YES	NO	NA
1. Is the temperature of all exposed parts less than 60 ^{o}C, when the ambient temperature is 25 ^{o}C, regardless of the condition of operation?			
2. Is the temperature of front panels and operating controls less than 49 ^{o}C, when the ambient temperature is 25 ^{o}C, regardless of the condition of operation?			
3. Is the release of toxic, corrosive, or explosive fumes or vapors prevented?			
4. Are the outer coverings of cables, wires, and other components free of glass fiber materials?			
OTHER SAFETY HAZARD			
ISSUE	YES	NO	NA
1. Are there provisions to prevent injury from implosion of cathode ray tubes?			
2. Is equipment designed to prevent accidental ignition of hazardous atmospheres? (Applicable to equipment that is intended for use in atmospheres of explosive gas or vapors, combustible dusts, or ignitable fibers and flyings.)			
3. Is a shut-down device or an alarm provided to prevent injury or equipment damage?			
4. Is there adequate separation between critical warning lights and other lights?			
5. Are audible warning signals distinguishable from other sounds under normal operating conditions?			
6. Are warning circuits separate from control circuits?			
7. Is the display lighting of aircraft electronics (avionics) compatible with the use of night vision goggles (NVG)?			

APPENDIX C. MOON RISE/SET AND ASTRONOMICAL TWILIGHT HOURS.

Location: W076 16, N39 23

EDGEWOOD, MARYLAND
Rise and Set for the Moon for 2009

Eastern Standard Time

Astronomical Applications Dept.
U. S. Naval Observatory
Washington, DC 20392-5420

	Jan.		Feb.		Mar.		Apr.		May		June		July		Aug.		Sept.		Oct.		Nov.		Dec.	
Day	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set
	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m
01	1015	2200	0956		0831	2317	0944	0034	1112	0056	1340	0054	1448	0016	1636	0050	1705	0231	1622	0322	1605	0519	1558	0627
02	1037	2303	1028	0015	0907		1053	0130	1224	0130	1445	0119	1552	0048	1722	0142	1731	0331	1645	0423	1639	0628	1656	0737
03	1100		1107	0126	0951	0029	1207	0217	1333	0159	1550	0145	1652	0124	1800	0239	1755	0432	1709	0525	1720	0738	1804	0840
04	1125	0008	1155	0239	1046	0138	1320	0255	1441	0225	1655	0213	1749	0206	1833	0339	1818	0532	1735	0629	1811	0848	1918	0934
05	1154	0116	1255	0348	1151	0240	1432	0327	1547	0249	1758	0246	1839	0254	1902	0439	1841	0633	1806	0735	1912	0954	2034	1018
06	1229	0228	1405	0450	1303	0334	1542	0355	1653	0315	1858	0324	1922	0348	1927	0540	1905	0735	1841	0844	2020	1051	2148	1055
07	1313	0343	1522	0542	1418	0419	1651	0421	1759	0342	1953	0408	1959	0446	1950	0640	1932	0839	1925	0953	2132	1140	2300	1126
08	1409	0457	1641	0624	1534	0455	1758	0446	1904	0412	2042	0459	2030	0546	2013	0740	2003	0945	2017	1100	2246	1220		1154
09	1516	0606	1758	0659	1647	0526	1905	0512	2007	0446	2123	0554	2058	0646	2036	0841	2040	1053	2119	1202	2358	1254	0010	1221
10	1633	0705	1911	0728	1759	0554	2012	0540	2106	0526	2158	0653	2122	0747	2100	0943	2126	1202	2228	1256		1323	0118	1248
11	1753	0753	2022	0755	1908	0620	2117	0612	2159	0613	2228	0753	2145	0847	2128	1047	2221	1308	2341	1341	0108	1351	0225	1316
12	1911	0832	2130	0820	2016	0645	2220	0649	2245	0705	2254	0854	2207	0946	2200	1153	2326	1408		1419	0217	1417	0332	1348
13	2026	0903	2237	0846	2124	0712	2317	0731	2324	0802	2318	0954	2231	1047	2240	1302		1500	0054	1452	0325	1444	0438	1424
14	2136	0931	2343	0913	2230	0741		0820	2357	0902	2340	1054	2256	1150	2330	1412	0038	1543	0207	1521	0434	1514	0542	1506
15	2243	0956		0943	2333	0815	0007	0914		1002		1155	2326	1256		1518	0154	1620	0319	1548	0542	1548	0642	1554
16	2349	1020	0047	1018		0853	0050	1012	0026	1103	0003	1258		1406	0030	1617	0309	1652	0429	1615	0649	1626	0735	1649
17		1046	0148	1058	0033	0938	0127	1112	0051	1204	0028	1403	0002	1517	0141	1707	0424	1721	0539	1644	0752	1711	0821	1747
18	0053	1113	0245	1145	0127	1028	0158	1214	0115	1305	0056	1513	0046	1628	0258	1749	0537	1748	0649	1715	0851	1802	0900	1847
19	0156	1144	0336	1237	0215	1124	0226	1316	0138	1408	0129	1626	0143	1734	0417	1824	0649	1816	0758	1751	0942	1858	0933	1947
20	0258	1220	0420	1335	0255	1224	0251	1418	0202	1514	0210	1740	0250	1831	0534	1855	0800	1846	0905	1832	1025	1957	1001	2046
21	0358	1302	0458	1436	0330	1325	0314	1521	0229	1623	0301	1850	0407	1918	0649	1923	0910	1919	1007	1920	1102	2057	1026	2145
22	0452	1351	0531	1538	0359	1428	0338	1626	0300	1736	0404	1953	0527	1956	0802	1950	1018	1956	1102	2012	1133	2157	1049	2243
23	0541	1446	0559	1641	0426	1530	0403	1735	0337	1851	0518	2045	0645	2028	0913	2018	1122	2040	1150	2109	1159	2256	1112	2342
24	0623	1545	0624	1744	0450	1634	0432	1846	0423	2005	0636	2126	0801	2057	1022	2048	1221	2129	1230	2209	1224	2355	1135	
25	0659	1647	0648	1847	0514	1738	0505	2000	0520	2111	0755	2201	0914	2124	1130	2122	1312	2223	1304	2309	1247		1200	0043
26	0729	1749	0711	1952	0538	1845	0545	2114	0628	2208	0910	2230	1024	2150	1235	2201	1356	2320	1333		1310	0055	1228	0146
27	0756	1852	0735	2058	0604	1954	0635	2224	0743	2253	1022	2257	1132	2218	1336	2246	1433		1359	0009	1334	0156	1302	0253
28	0820	1954	0801	2206	0633	2105	0736	2325	0859	2330	1131	2322	1238	2249	1431	2336	1505	0020	1423	0109	1401	0259	1344	0402
29	0843	2056			0708	2218	0844		1014		1237	2348	1343	2323	1519		1533	0121	1446	0209	1433	0406	1436	0512
30	0905	2200			0750	2329	0958	0015	1125	0001	1343		1446		1600	0032	1558	0221	1510	0310	1511	0516	1539	0619
31	0930	2306			0842				1233	0028			1544	0004	1635	0130			1536	0413			1652	0719

Add one hour for daylight time, if and when in use.

NOTE: BLANK SPACES IN THE TABLE INDICATE THAT A RISING OR A SETTING DID NOT OCCUR DURING THAT 24 HR INTERVAL.

Moon Set in Edgewood Maryland at 1302 on 21 January 2009.

Location: W076 16, N39 23

EDGEWOOD, MARYLAND
Astronomical Twilight for 2009

Eastern Standard Time

Astronomical Applications Dept.
U. S. Naval Observatory
Washington, DC 20392-5420

	Jan.		Feb.		Mar.		Apr.		May		June		July		Aug.		Sept.		Oct.		Nov.		Dec.	
Day	Begin	End	Begin	End	Begin	End	Begin	End	Begin	End	Begin	End	Begin	End	Begin	End	Begin	End	Begin	End	Begin	End	Begin	End
	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m
01	0549	1829	0540	1858	0509	1927	0417	2001	0324	2041	0243	2123	0242	2135	0318	2104	0359	2010	0432	1916	0502	1834	0531	1817
02	0549	1830	0539	1859	0507	1928	0415	2003	0322	2043	0243	2124	0243	2135	0319	2102	0400	2008	0433	1915	0503	1833	0532	1817
03	0549	1830	0539	1900	0506	1929	0414	2004	0321	2044	0242	2125	0244	2135	0321	2100	0402	2006	0434	1913	0504	1832	0533	1817
04	0549	1831	0538	1901	0504	1930	0412	2005	0319	2046	0241	2126	0244	2134	0322	2059	0403	2004	0435	1912	0505	1831	0533	1817
05	0549	1832	0537	1902	0503	1931	0410	2006	0317	2047	0241	2127	0245	2134	0324	2057	0404	2002	0436	1910	0506	1830	0534	1817
06	0550	1833	0536	1903	0501	1932	0408	2007	0316	2049	0240	2128	0246	2133	0325	2056	0405	2000	0437	1908	0507	1830	0535	1817
07	0550	1834	0535	1904	0500	1933	0406	2009	0314	2050	0239	2129	0247	2132	0326	2054	0406	1959	0438	1907	0508	1829	0536	1817
08	0550	1835	0534	1905	0458	1934	0405	2010	0313	2052	0239	2130	0248	2132	0328	2052	0407	1957	0439	1905	0509	1828	0537	1818
09	0550	1835	0533	1906	0456	1935	0403	2011	0311	2053	0239	2131	0249	2131	0329	2051	0409	1955	0440	1904	0510	1827	0537	1818
10	0549	1836	0532	1907	0455	1936	0401	2013	0310	2054	0238	2131	0250	2130	0331	2049	0410	1953	0441	1902	0511	1826	0538	1818
11	0549	1837	0531	1908	0453	1937	0359	2014	0308	2056	0238	2132	0251	2129	0332	2047	0411	1951	0442	1901	0512	1826	0539	1818
12	0549	1838	0530	1909	0452	1939	0357	2015	0307	2057	0238	2133	0252	2128	0333	2046	0412	1949	0443	1859	0513	1825	0539	1818
13	0549	1839	0529	1910	0450	1940	0356	2016	0305	2059	0237	2133	0253	2128	0335	2044	0413	1948	0444	1858	0514	1824	0540	1819
14	0549	1840	0528	1911	0448	1941	0354	2018	0304	2100	0237	2134	0255	2127	0336	2042	0414	1946	0445	1856	0515	1824	0541	1819
15	0549	1841	0527	1912	0447	1942	0352	2019	0302	2102	0237	2134	0256	2126	0337	2040	0415	1944	0446	1855	0516	1823	0541	1819
16	0548	1842	0526	1913	0445	1943	0350	2020	0301	2103	0237	2135	0257	2125	0339	2039	0416	1942	0447	1854	0517	1822	0542	1820
17	0548	1843	0524	1914	0443	1944	0348	2022	0300	2104	0237	2135	0258	2123	0340	2037	0417	1940	0448	1852	0518	1822	0543	1820
18	0548	1844	0523	1915	0442	1945	0347	2023	0258	2106	0237	2136	0259	2122	0341	2035	0419	1939	0449	1851	0519	1821	0543	1820
19	0548	1845	0522	1916	0440	1946	0345	2024	0257	2107	0237	2136	0301	2121	0343	2033	0420	1937	0450	1850	0520	1821	0544	1821
20	0547	1846	0521	1917	0438	1947	0343	2026	0256	2108	0237	2136	0302	2120	0344	2032	0421	1935	0451	1848	0521	1820	0544	1821
21	0547	1847	0519	1918	0437	1949	0341	2027	0254	2110	0237	2136	0303	2119	0345	2030	0422	1933	0452	1847	0522	1820	0545	1822
22	0546	1848	0518	1919	0435	1950	0339	2029	0253	2111	0238	2137	0304	2118	0347	2028	0423	1932	0453	1846	0523	1819	0545	1822
23	0546	1849	0517	1921	0433	1951	0338	2030	0252	2112	0238	2137	0306	2116	0348	2026	0424	1930	0454	1844	0524	1819	0546	1823
24	0545	1850	0516	1922	0431	1952	0336	2031	0251	2114	0238	2137	0307	2115	0349	2024	0425	1928	0455	1843	0525	1819	0546	1823
25	0545	1851	0514	1923	0430	1953	0334	2033	0250	2115	0239	2137	0308	2114	0351	2022	0426	1926	0456	1842	0526	1818	0547	1824
26	0544	1852	0513	1924	0428	1954	0332	2034	0249	2116	0239	2137	0310	2112	0352	2021	0427	1925	0457	1841	0526	1818	0547	1825
27	0544	1853	0511	1925	0426	1955	0331	2036	0248	2117	0240	2136	0311	2111	0353	2019	0428	1923	0458	1840	0527	1818	0547	1825
28	0543	1854	0510	1926	0424	1957	0329	2037	0247	2119	0240	2136	0312	2109	0354	2017	0429	1921	0459	1839	0528	1818	0548	1826
29	0542	1855			0423	1958	0327	2039	0246	2120	0241	2136	0314	2108	0356	2015	0430	1920	0500	1837	0529	1818	0548	1827
30	0542	1856			0421	1959	0326	2040	0245	2121	0241	2136	0315	2107	0357	2013	0431	1918	0501	1836	0530	1817	0548	1827
31	0541	1857			0419	2000			0244	2122			0317	2105	0358	2011			0501	1835			0549	1828

Add one hour for daylight time, if and when in use.

Astronomical Twilight ends in Edgewood Maryland at 1847 on 21 Jan 2009

APPENDIX D. REFERENCES.

1. ANSI/NCSL Z540.3, Requirements for the Calibration of Measuring and Test Equipment, 1 January 2006.

2. ISO 10012, Measurement Management Systems – Requirements for Measurement Processes and Measuring Equipment, 15 April 2003.

3. MIL-STD-882D, Department of Defense Standard Practice for System Safety, 10 February 2000.

4. TOP 10-2-508, Safety and Health Hazard Evaluation - General Equipment, 6 May 1980.

5. TOP 02-2-614, Toxic Hazards for Vehicles and Other Equipment, 31 Oct 2003.

6. TOP 01-2-504. Physical Characteristics, 31 October 1972.

7. MIL-L-44259C, Light Set, Portable, Fluorescent, 19 November 1990.

8. AR 70-38, Research, Development, Test and Evaluation of Materiel for Extreme Climatic Conditions, 15 September 1979.

9. ASTM E 1925-04, Specification and Design Criteria for Rigid Wall Relocatable Structures, 9 January 2007.

10. MIL-STD-461F, Department of Defense Interface Standard, Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment, 10 December 2007.

11. TOP 01-2-511, Electromagnetic Environmental Effects System Testing, 21 September 2009.

12. MIL-STD-810G, Environmental Engineering Considerations and Laboratory Test Methods, 31 October 2008.

13. TOP 01-2-500, Transportability, 15 September 2008.

14. TOP 01-2-501, Rail Impact Testing, 15 September 2008.

15. TOP 01-2-621, Outdoor Sand and Dust Testing, 6 February 2009.

16. TOP 01-2-610, Human Factors Engineering (PART I – TEST PROCEDURES, PART II - HEDGE), 15 May 1990.

17. TOP 01-1-030, RAM-D and ILS Analysis, 8 September 2008.

18. MIL-HDBK-781A, DoD Handbook for Reliability Test Methods, Plans and Environments for Engineering, Development, Qualification and Production, 1 April 1996.

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